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Depth Dependence of Shear Properties in Articular Cartilage MARK BUCKLEY, JASON GLEGHORN, LAWRENCE BONASSAR, ITAI COHEN, Cornell University — Articular cartilage is a highly complex and heterogeneous material in its structure, composition and mechanical behavior. Understanding these spatial variations is a critical step in designing replacement tissue and developing methods to diagnose and treat tissue affected by damage or disease. Existing techniques in particle image velocimetry (PIV) have been used to map the shear properties of complex materials; however, these methods have yet to be applied to understanding shear behavior in cartilage. In this talk, we will show that confocal microscopy in conjunction with PIV techniques can be used to determine the depth dependence of the shear properties of articular cartilage. We will show that the shear modulus of this tissue varies by over an order of magnitude over its depth, with the least stiff region located about 200 microns from the surface. Furthermore, our data indicate that the shear strain profile of articular cartilage is sensitive to both the degree of compression and the total applied shear strain. In particular, we find that cartilage strain stiffens most dramatically in a region 200-500 microns below the surface. Finally, we will describe a physical model that accounts for this behavior by taking into account the local buckling of collagen fibers just below the cartilage surface and present second harmonic generation (SHG) imaging data addressing the collagen orientation before and after shear.

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